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The aims of the research are to study the effects of response mode, response complexity, instructions and practice on basic cognitive tasks, and to use the information obtained to develop more elaborated models of cognitive functioning which take these factors into account. To accomplish these aims, subjects will be tested on a set of computer-administered cognitive tasks, using keyboard and touch screen response modes, and under varying sets of verbal and nonverbal instructions.

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Annual Technical Report

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Project Title

Response Devices and Cognitive Tasks

AFSRO-90-0084

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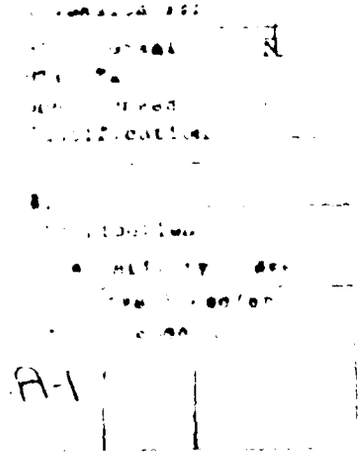

Objectives of the Research Effort

The aims of the research are to 1) study the effects of response mode, response complexity, instructions and practice on basic cognitive tasks, and 2) to use the information obtained to develop more elaborated models of cognitive functioning which take these factors into account. To accomplish these aims, subjects will be tested on a set of computer-administered cognitive tasks, using both keyboard and touch screen response modes, and under varying sets of verbal and nonverbal instructions.

STATUS OF RESEARCH EFFORT

The experiments proposed for Year 1 have been completed and analyzed. Results have been presented at several conferences (see below for information). Several additional experiments have also been completed which bear on the issue of response factors in cognitive tasks. The following is a brief abstract of each of the experiments completed and their results.

Response devices. This experiment compared touch screen responding to the standard keyboard method of collecting data. Responses were compared on a wide variety (10) cognitive tasks. The general conclusion from this comparison is that touch screens reduce the demands of cognitive tasks. It was expected that response measures would be faster and this was found. An unexpected finding was that other measures also showed better performance. For example, decision time measures which were not directly affected by decreased response demands also showed improvement. Improvement was not confined to speed measures. Some measures of correct responding also showed improvement.

This set of important findings suggest that the complication of response factors can interact with other portions of a cognitive task. Donder's notions of additivity certainly don't seem to apply to the use of touch screens to replace keyboard responding. When touch screens are used, not only does the response get easier but so do other parts of the task.

Reaction time response complexity. To follow up on the touch screen finding, an experiment was designed which deliberately manipulated response complexity in the reaction time task. In the reaction time task, as subject touches the space bar and then lifts his finger as soon as a box on the screen lights up. The time it takes the subject to lift his finger after the light comes on is called decision time. After lifting his finger, the subject responds. The response a subject makes has no logical relationship to the decision time component. If subjects behave according to Donder's notions of simple additivity, the complexity of the response should have no affect on decision time. That is what this experiment was designed to test.

Subjects completed a 120 item reaction time task under various conditions of response complexity. In all conditions subjects were told that they were being tested on how fast they lifted their finger from the bar (decision time). In the simplest condition, subjects simply lifted their finger from bar and made no response (RN). In the other three conditions, subjects were required to touch either the D or G key on the keyboard using various rules differing in complexity. In the RA condition, the subject could touch any key before responding. In the RS condition, the subject touched the D key if the position lighted was on the left and the G key if it was on the right. In other words, they touched the key on the same side as the lighted square. In the RO condition, subjects touched the D key if the position lighted was odd and the G key if it was even (Odd-even). The conditions were progressively more difficult in the order they were described.

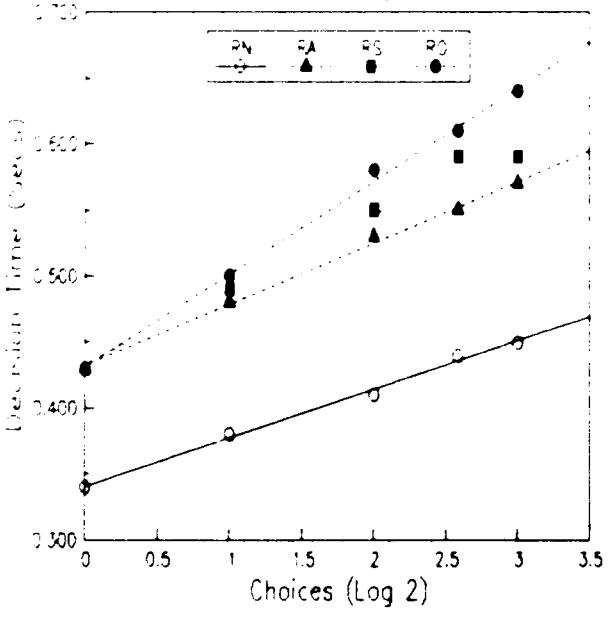

Figure 1. The affect of response complexity on decision time.

Figure 1 shows the results of this experiment. As is obvious, the more complex the response alternative the longer was the decision time. All of the effects represent significant main and interaction effects. Also of interest is the interaction of response complexity with the number of choices. The number of choices refers to the number of alternative windows on the screen that can light up during the reaction time task.

There is a confounding in the reaction time task between the complexity of searching the choices and the complexity of making the response. It is this confounding that produces the shape of lines shown in Figure 1. When there is a single choice, all of the response rules are equally difficult. But as alternatives are added, the more complex responses actually do become more complex.

The fact that the RN (no response) condition is so much easier than any of the other conditions indicates the cost of adding an extra key press to the response. Remember, there is no necessary reason for this condition to affect the decision time measure shown in Figure 1.

Reversing Hicks Law. Hick's is the finding that decision time increases with number of alternatives. It is possible that Hick's law could be produced entirely by response complexity. By reversing response complexity, it might be possible to reverse Hick's law. In this experiment, the 1 alternative condition was assigned the RO response condition, the 2 alternative condition was given the RS condition, the 4 alternative condition the RA response condition, the 6 alternative condition simply pressed a key, and the 8 alternative

condition was assigned the RN response condition. These conditions were within-subject so every subject received every condition in a single presentation of the 120 trial reaction time task.

The preliminary results of this experiment show that response complexity can, in fact, reverse Hick's law. Current results show a negative slope for decision time when plotted against number of alternatives. While this experiment shows clearly that response factors interact clearly with decision factors, they do not show how that Hick's law is due entirely to response complexity, although that is a possibility.

Touch screen - simplified. This experiment is just getting under way. The purpose is to simplify the response component of the reaction time task to determine if Hick's law still applies. In this experiment, subjects will do the standard reaction time task with positions and blocks randomized. The only response required will be to lift a finger when the light comes on. The response will be the same for all numbers of alternatives.

Verbal and Nonverbal Instructions. The experiments regarding tasks presented without instruction are fully described in Detterman and Andrist (1990).

Other experiments. Data has been collected on a number of other issues less central to the main purpose of this grant. These data have not yet been fully analyzed.

Project time table. This project has fallen behind schedule. We have requested a one year no-cost extension to complete the proposed work. While the work could be completed within the time allowed, quality would suffer.

Publications during the Period:

Detterman, D. K. *(1989).* Changing intelligence? [Review of *The raising of intelligence: A selected history of attempts to raise retarded intelligence.]* *American Journal of Mental Retardation*, **93**, 461-462.

Detterman, D. K. (1989). Common challenges in understanding human and artificial intelligence. [Review of *Creative Intelligences.*] *Contemporary Psychology*, **34**, 495.

Kahana, M. J. & Detterman, D. K. (1989). ABC: A program to convert PSYCHLIT CD-ROM abstracts into APA style bibliographies. *Behavior Research Methods, Instruments and Computers*, **21**, 414.

Detterman, D. K. (1989). The Future of Intelligence Research (Editorial). *Intelligence: A Multidisciplinary Journal*, 13, 199-203.

Detterman, D. K., & Daniel, M. H. (1989). Correlations of mental tests with each other and with cognitive variables are highest for low IQ groups, *Intelligence*, **13, 349-359.

Detterman, D. K. (1989). Cognitive psychology: Why it succeeded and then failed. [Review of *Advances in the psychology of human intelligence, volume 4*), *Contemporary Psychology*, **34**, 778-779.

Detterman, D. K. (1989). The power of intelligence. In J. G. Beaumont (Ed.), *Brainpower*. London: Andromeda Oxford Limited.

*Detterman, D. K. (1990). Don't kill the ANOVA messenger for bad interaction news. *Behavior and Brain Sciences*, **13**, 131-132.

Detterman, D. K. & Andrist, C. G. (1990). The effects of instruction on elementary cognitive tasks sensitive to individual differences. *American Journal of Psychology*, **103, 367-390.

Detterman, D. K. (Ed.). (in press). *Current topics in human intelligence: Vol. 2, Is mind modular or unitary?* Norwood, NJ: Ablex Publishing Corporation.

Andrist, G. A., Kahana, M. J., Spry, K. M., Knevel, C. R., Persanyi, M. W., Evans, S. W., Luo, D., & Detterman, D. K. (in press). Individual differences in the biological correlates of intelligence: A selected overview. In D. K. Detterman (Ed.), *Current topics in human intelligence: Vol. 2, Is mind modular or unitary?* (pp. 000-000). Norwood, NJ: Ablex Publishing Corporation.

Detterman, D. K. (1990). Computerized cognitive abilities tests for research and teaching. *Micro Psych*, **4**(3), 51-62.

Detterman, D. K. (1990). Computerized cognitive abilities tests for research and teaching. *Micro Psych*, **4**(3), 51-62.

Detterman, D. K., Thompson, L. A., Plomin, R. (1990). Differences in heritability across groups differing in ability. *Behavior Genetics*, **20**, 369-384.

*Detterman, D. K. (1990). Don't kill the ANOVA messenger for bad interaction news. *Behavioral and Brain Sciences*, **13**, 131-132.

*Thompson, L. A., Detterman, D. K., Plomin, R. (1991). Associations between cognitive abilities and scholastic achievement: Genetic overlap but environmental differences. *Psychological Science*, 2, 158-165.

Detterman, D. K. (1991). Is g intelligence or stupidity: Reply to Deary and Pagleari. *Intelligence*, 14,

Andrist, C. G., Kahana, M. J., Spry, K. M., Knevel, C. R., Persanyi, M. W, Evans, S. W., Luo, D., & Detterman, D. K. (1991). Individual differences in the biological correlates of intelligence: A selected overview. In Detterman, D. K. (Ed.), *Current topics in human intelligence, Vol. 2, Is mind modular or unitary?* (pp.). New Jersey: Ablex Publishing Corp.

*Detterman, D. K. (Ed.). (1991). *Current topics in human intelligence: Vol. 2. Is mind modular or unitary?* Norwood, NJ: Ablex Publishing Corporation.

*Detterman, D. K., & Sternberg, R. J. (in press). *Transfer on trial: Intelligence, cognition and instruction*. Norwood, NJ: Ablex Publishing Corporation.

*Detterman, D. K. (in press). The case for the prosecution: Transfer as an epiphenomenon. In D. K. Detterman & R. J. Sternberg (Eds.), *Transfer on trial: Intelligence, cognition and instruction*. Norwood, NJ: Ablex Publishing Corporation.

Fagan, J. F., & Detterman, D. K. (in press). The Fagan Test of Infant Intelligence. *Journal of Applied Developmental Psychology*.

Detterman, D. K. (Ed.). (in press). *Current topics in human intelligence: Vol. 3.* Individual differences in cognition. Norwood, NJ: Ablex Publishing Corporation.

Detterman, D. K. (Ed.). (in press). *Current topics in human intelligence: Vol. 4.* Theories of Intelligence. Norwood, NJ: Ablex Publishing Corporation.

Detterman, D. K. (in press). Levels of abilities. In Sternberg, R. J. & Wagner, R. K. (Eds), *Mind in Context: Interactionist perspectives on human intelligence*. Cambridge University Press.

Professional Personnel

Personnel associated with project:

**Andrist, Charlotte G. Ph.D. degree expected August, 1990. Dissertation topic: A Ravens-Like Perceptual Task.

**Spry, Kathleen M. M.A. degree awarded 1990. Thesis title: A Progressive Matrices Test for the CAT Battery.

Luo, D. Ph.D. Degree to be awarded in 1992. Dissertation project deals with application of item response theory to cognitive tasks.

Papers presented at Professional Meetings

*Detterman, D. K., & Thompson, L. A. (June, 1989). *Differences in heritability across levels on intelligence*. Paper presented at the annual meeting of the Behavior Genetic Association, Charleston, VA.

**Detterman, D. K. (1989, November). *Are mental processes the same across the ability spectrum?* Paper presented at the 30th annual meeting of the Psychonomic Society, Atlanta, GA.

*Detterman, D. K. (1990, April). *Transfer: The case for the prosecution*. Paper presented at the annual meeting of the American Educational Research Association, Boston, MA.

Detterman, D. K., & Persanyi, M. (1990, April). *Differences in correlation across ability level in the K-ABC*. Paper presented at the annual meeting of the American Educational Research Association, Boston, MA.

**Andrist, C. G., & Detterman, D. K. (1990, April). *The relationship between perceptual structure and individual differences on performance on Raven's Advanced Procgressive Matrices*. Paper presented at the annual meeting of the American Educational Research Association, Boston, MA. Won award for best paper presented by a student.

**Detterman, D. K. (1991, August). Reaction time, decision time, and movement time. Part of a symposium presented at the annual meeting of the American Psychological Association, San Francisco.

Petrill, S. A., Thompson, L. A., & Detterman, D. K. (1991, September). The phenotypic and genetic relationship among general intelligence, psychometric specific cognitive abilities, & elementary cognitive tasks. Poster presented at the Behavior Genetic LISREL Conference, Leuwen, Belgium.

**Detterman, D. K. (1991, October). The complexities of reaction time. Invited talk at the SMART symposium, University of Toronto.

Note: *Those items above with a single asterisk indicate publications or presentations where the assistance of Air Force support is acknowledged. **Those items with a double asterisk indicate publications or presentation where Air Force support is acknowledged and data collected with Air Force support is reported.

CONSULTATION\ADVISORY

Federal Government. Detterman has been appointed to the National Institute of Health, Human Development III study section.

Air Force. Detterman has provided consultation concerning installation of touchscreens. He has also provided some software that he has developed to HRL personnel. For example, Dr. William Tirre was provided with a copy of a progressive matrices test developed in Detterman's lab. Once the touch screens are installed, Detterman will be providing consultation on use of the touch screens. He will also provide software previously developed for use of the touch screens.

Budget for Next Year. No budget is proposed for a third year. Though a third year of time is requested, it is at no cost to the Air Force.